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INFLUENCE OF RAINFULL VARIABILITY ON THE CULTIVATION OF COWPEA *(VIGNA UNGUICULATA(L.) WALP(L.)* IN THE MUNICIPALITY OF LOKOSSA IN BENIN

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ABSTRACT

Cowpea, is the most leguminous cultivated in the Municipality of Lokossa as a source of protein and significant energy for populations. This study is aimed to analyse impacts of rainfall variability on the cultivation of Cowpea in this municipality. So the methodology is essentially based on documentary research and field work based on the purposive sampling method taking into account 235 farmers. The ten-day, monthly and annual data of 1981-2011 and rainfall agricultural statistics of 1995-2011 were used in order to analyze the agro-climatic conditions, the Franquin climate balance, and also the water balance of the Cowpea cultivation to verify the critical phases of this culture. The analysis of data shows that the period (1981-2010) dry season are becoming more important than wet season. Indeed, the water needs are not sufficient throughout cowpeas 'cycle during the years considered. In 1981, apart from the flowering period where the availability exceeds of 1.73 mm with a quite lack of rain in the lifting period, the other phases of development of cowpeas were submitted to deficit water. In the light of these various comments, the cropping strategies developed by farmers are the adoption of new varieties of crops with short cycle (80%), the association of cultures (20 %), the redevelopment of the agricultural calendar (90%), cultures of off-season (3%), rituals to exorcise the evil spells to improve agricultural production.

KEYWORDS: Lokossa, Rainfall Variability, Cowpea, Adaptation of Strategy

INTRODUCTION

Agriculture in tropical Africa is still heavily dependent on seasonal or annual rainfall regimes. In the developing countries in general and those of sub-Saharan Africa, in particular, agricultural development is considered a priority sector (Atchadé, 2007). In Benin, agriculture occupies a prominent place in the economy; employs about 70% of the active population (MAEP, 2009). In rural areas, the main activity is subsistence agriculture for self-consumption highly threatened by bad weather that make uncertain agricultural production (Séidou, 2012). This variation is often characterized by an increase in temperatures, a reduction of the amounts of annual rainfall and the number of days of rain (Mingnannou, 2011). Indeed, in the South of the country, except the coastal area where the trend is the increase in rainfall, there is a deficit, and a shortening of the second rainy season (PANA-BENIN, 2007), who has also the yields of the order of 600 to 700 kg/ha in this area for corn, which is not only extremely low, but could fall further as a result of climate disturbances

more frequent. In this context, the producers of the Municipality of Lokossa associate this cereal to leguminous such as cowpeas to improve their diet and their agricultural productivity (Adjahossou *et al*. 2009). In fact, the cowpea, *Vigna unguiculata* (l.) Walp., is one of the main global food leguminous. It is grown on more than 9 million hectares in the Tropics (Pasquet and Baudoin, 1998) and offers a rich source of relatively cheap protein for the majority of West African consumers on low income. Apart from its nutritional value where it is consumed during the field work by the producers of the Municipality of Lokossa as source of protein and energy, this culture is also used for the induction ceremonies and rituals. For its culture, Cowpea only requires a temperature range between 25 and 28 ° C and a rainfall of 500 to 800 mm. The growth cycle is about 70 days. West and Central Africa covers about 80% of the area of Cowpea in the world, Nigeria is the largest producer of cowpeas in the world but also the biggest importer. Niger is the second largest producer in the world. Other producers of the ECOWAS are, in order of importance, Burkina Faso, Mali, Benin, Ghana, Togo, Senegal and Côte d'Ivoire (Langyintuoa *et al*, 2003). Cowpea is produced mainly in the arid interior of the West Africa due to its drought tolerance and less pressure from insects in these areas. Thus, in the Municipality of Lokossa, Cowpea production is declining and strongly influenced by the climate pejoration despite the availability of cultivable land and exploitable water resources based on field investigations. This study is a contribution to a better understanding of the impacts of rainfall variability on agricultural production, as well as developed in the common coping strategies.

STUDY AREA

Lokossa is one of the six municipalities of the Department of Mono. It is between 6 ° 35' and 6 ° 46' North latitude and between 1 ° 34'5 "and 1 ° 55' longitude. The climate is of subequatorial type and is also called “climat beninien”. It's a warm climate marked by relatively high humidity, rainfall ranging between 900 and 1100 mm per year, including seven months of rains that extends from March to July and August to November (Municipality, 2011). According to data from ASECNA, monthly average rainfall of the district is of bimodal type with two peaks; one in June (152,1 mm), the other in October (129 mm). The lowest levels of this series are between 17 mm for the month of December and 7.7 mm for the month of January.

Production of Cowpea in Municipality is mostly done on hydromorphicoriron baring soils.

METHODOLOGICAL APPROACH

The climate data used concerns the amounts of rainfall, decadal, monthly and annual potential evapotranspiration and relative humidity (1980-2010), decadal, monthly and yearly rainfall of pluviometric station of Lokossa and pluviometric station of Bohicon being closest to the study area. They have allowed to appreciate the rainfall variability; the evolution of the moisture and encrypt the water needs of the culture of Cowpea. So, to better understand the influence of climate variability on the production of cowpea, statistical data of the “CARDER” have been collected.

Similarly, the demographic data of the “INSAE” on farm households have allowed to develop sampling of farm households and target groups surveyed. Surveyed farmers are indigenous people practicing the culture of Cowpea and being aged of at least 40 years. To achieve this, the purposive sampling method was adopted. The Municipality of Lokossa has 8570 farm households, and a sampling of 235 agricultural households was realized. Thus, eleven (11) villages / neighbourhoods have been visited. Several techniques and tools have been selected and adopted. Among other direct observation and semi-directs interviews, the method of quota, the Active Participative research method, focus groups has been made in some visited neighbourhoods/villages, using a questionnaire, addressed to the resource people such as: The

District Chief or the wise men.

Methods

Climate variability has been characterized from the methods of descriptive statistics such as: the mean and the standard deviation for the calculation of anomalies. The humidity index (HI) and agroclimatic stress index (ASI) were used to assess the agricultural climatic condition of the environment to study and have respectively as formula:

HI = $(\Sigma P/\Sigma \boldsymbol{ETP}) \times 100$ and ASI (%) = $[(\sum ETP-\sum ETR)/\sum ETP] \times 100$ with P = seasonal precipitation in mm, ETP= potential evapotranspiration in mm, ETR = Real evapotranspiration

The collected data were processed by using the Excel 2010 software. Deficit and surplus of 1971-2010 normal years have been identified by considering that there is deficit when the value of the reduced centered gap is less than-1 and surplus when it has a value of + 1.

Potential Climatic Assessment of the Study Area

The climate balance is obtained by the difference between the total rainfall offal and the value of evapotranspiration (ETP), which is the surplus available for recharging the ground water and the flow (Vissin, 2001).

The formula of the climate balance is the following:

Bc = P – ETP with Bc the climate balance in mm and P total rain in mm

Bc< **0**; the balance is in deficit; Bc > **0**; 0, the balance is in surplus;Bc = 0, the balance is stable

Cowpea Water Balance Assessment

The crop water balance determines the water needs of crops during their development through the cultural coefficient (Kc); determined experimentally for each variety relatively to their phenophases. For this study the second decade of the month of April is the reference chosen for growing cowpeas which is the period limit of seedlings for the majority of producers of the Municipality of Lokossa. The first step was the calculation of the water demand of crops which translates as the product of the cultural coefficient to the ETP of each phenophase during the vegetative (ETP × Kc). Then the balance sheet of water of the Cowpea was established by taking the difference between the precipitation (P) of the period and the water demand corresponding.

RESULTS AND DISCUSSION

Precipitation Anomalies

Figure 1 has shows the precipitation indices of the Municipality and translated strong Interannual variability in the amount of the rainfall. The analysis of figure allows pointed out of the study period alternating years of deficits (1981,1982, 1983, 1984, 1986, 1992, 1994, 1998, 2000, 2001, 2002, 2003, 2004, 2005, 2007, 2010) and excess (1987, 1989,1995, 1996, 1997, 1999, 2006,1997, 2009).

The period is then characterized by considerable instability in the evolution of precipitation. But it is worth noting the large number of deficit water years fifteen (15) against eight (08) excess water years.

Whether 50% of deficit water years against 26, 67% of excess water years. This condition will affect no doubt the yields of cowpeas in the Municipality of Lokossa. So, the climate parameters such as the potential evapotranspiration

(ETP)-based method of Franquin and decadal rainfall are climate parameters which determine agroclimatic seasons.

Determination of Agroclimatic Season

Figure 2 has indicated agroclimatic season in 1981 deficit water year in the municipality of Lokossa..

This year recorded a very bad distribution of precipitation. Dry periods correspond to the second decade of May, in the second and third decades of June, in the second decade of July to September and in the third decade of the month from September to May. It lasts so 290 days with two periods of drought of twenty days during the rainy season and the other 70 days during the dry season of 70 days. The relatively wet period was then recorded sixty-five (65) wet days. So it is a stressful condition for the harmonious development of the plants.

Figure 3 shows the agro climatic seasons in excess water year 2009. However, the excess water year of 2009 has caracterized by 70 days of humidity, among which fifty (50) days were well distributed during the great rainy season with a break of twenty days in May and twenty (20) humid days badly distributed to the last season.

Analysis of the Agro climatic Conditions and Cowpea Water Balance

Figure 4 shows inter annual fluctuation of humidity and stress agroclimatic indices in the Municipality with a peak observed in 2009 reflecting an excess of humidity in the soil. The lowest value is recorded in 1983 reflecting high water demand for most cultures in the study area. The water balance of cultures during these critical years of deficits (1981, 1987) or excess (2000, 2009) indicates about the condition crops in these periods. The following table traces the need and the Cowpea water balance according to its cycle of development. According to the analysis of this table (Table 1) which presents the evolution of deficits or excess in cowpea water, water balance varies with each phase of development of the studied cultures. Similarly, the water demand of the Cowpea is not sufficient throughout the cycle of development of culture for the years in question.

Apart from the flowering period, all other phases of development of culture have experienced serious deficits in water whether in year deficit (1981, 1987) or excess (2000, 2009). The work carried out by Doukpolo (2014) in Central Africa has shown that the ten-day periods from 1971-1980 and 1981-1990 are distinguished by marked deficits.

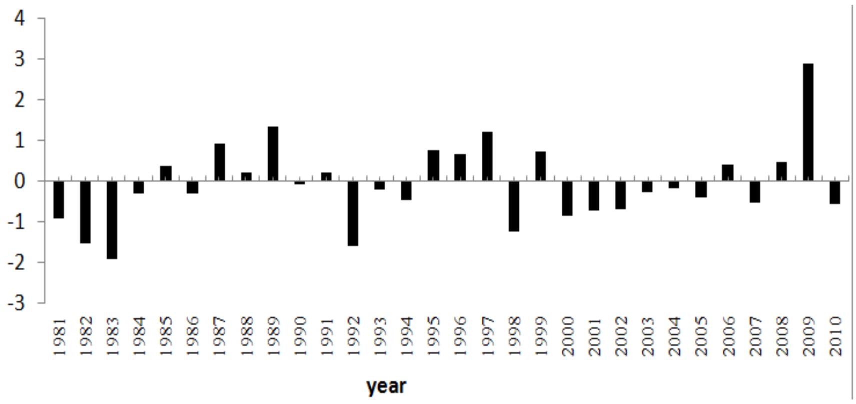

Figure 1: Precipitation Index of the Municipality of Lokossa, Source: ASECNA, 2013

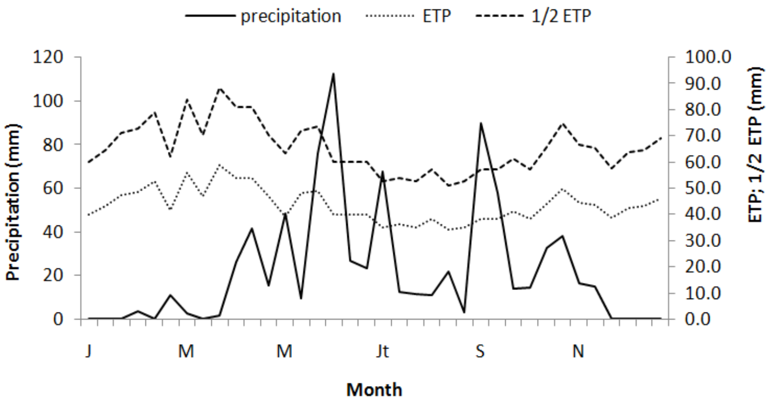

Figure 2: Agroclimatic Seasons in 1981 Deficit Water Year, Source: ASECNA, 2013

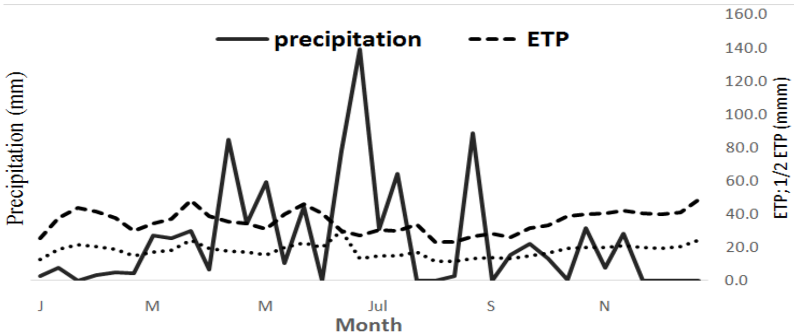

Figure 3: Agroclimatic Seasons in Excess Water Year 2009 at Lokossa, Data Source: ASECNA, 2013

On the other hand, the last two ten-day periods (1990-2000 and 2001-2010) are characterized by an alternation of the excess and deficit water years, but with a relative dominance of excess rainfall that began in the early 2000s.Explained by the fact that the performance of cowpeas in the Municipality of Lokossa in Benin is spent during this period of 303 kg /ha in 1998 to almost 600 kg/ha in 2007 according to the statistics of the Ministry of Agriculture, livestock and fishing. In 1981, Cowpea has experienced deficit in all phenological phases, except at flowering or availability more than 1.73 mm with a total lack of rain. In add, this crop even in condition of water stress accumulated most of its water needs in the tissues during the first 30 days of the cycle of development at the expense of growth in height of the plant (Uarrota, 2010; Paul de N'Gbesso *et al*., 2013). What explains its great adaptability in areas of low rainfall (Barros *et al.* 2007). In 1987, the deficit is 35.8 mm at heading. In excess (2000), Cowpea respectively recorded a deficit of 23.2 mm and 68.8 mm lifting and maturity. Indeed the good vegetative development largely determines the final yield, a stress during flowering lengthens the male flowering interval / female flowering, decreases in flower fertility and induces abortion of ovules, then the grains. If the crop is suffering during the grain filling, it's the weight of grains which is decreased. In Nigeria, Yamusu *et al*., (2015) confirmed that only 5 drought days impacted negatively on the yield of crop. In conclusion, hydric stress will always have negative performance on the yield crop regardless of the period where it occurs.

RAINFALL AND YIELD OF COWPEA

Figure 5 shows the relationship between the yield of Cowpea and the precipitation during 16 years. In the aggregate, the two studied parameters present the same pace, which implies the existence of a relationship between two variables. To an amount of rainfall of 1348,6 mm in 1997, the performance was 1 366 kg/ha. Under a rainfall of 993,4 mm

in 2004 a performance of 1 011 kg/ha was registered. In 2010 (year deficit), performance decreases considerably and reached 629 kg/ha.

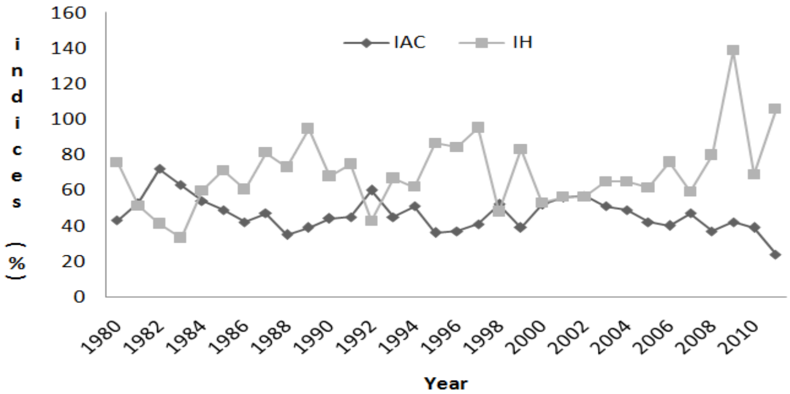

Figure 4: Evolution of the Agroclimatic Indices in Lokossa, Data Source: ASECNA, 2013

Table 1: Evolution of Deficits or Excess in Cowpea Water

Cowpea with a Short Cycle (70 Days)													
Deficit Year_								Excess Year					
1981					1987			2000			2009		
Variables / Phases	D	P	Bec	Dec ou Eec	P	Bec	Dec ou Eec	p	Bec	Dec ou Eec	p	Bec	Dec ou Eec
Seedling and Lifting	1	0	19,6	19,6 ***	85,2	13,1	72,14*	41,3	18,1	23,2 ***	62,7	18,13	44,6*
Flowering	2	86 ,3	84,6	1,73*	94,3	56,1	38,2*	63,4	73,8	10,4*	64,3	76,23	11,9*
Fructification	2	21,9	99,3	77,4 ***	54,9	90,7	35,8 ***	85	101,8	16,8*	82	98,7	16,7 ***
Maturity	2	52,6	73,3	20,7 ***	78,4	63,1	15,3*	139	70,2	68,8 ***	61,6	67,59	6 ***

Data Source : ASECNA, 2013 et LSSEE, 2004

*D: ten-day periods; Deficit values; * excess values; P: precipitation (mm); BEC: water requirement of crops by step of development (mm); Dec or Ec: deficit or excess water crops (mm)*

It is the same for the years 2004 and 2005. Indeed, Atchade (2007) showed that the rainfall pejoration leads to the decline in the production of crops per unit area. Faced with factors of climate, particularly rainfall variability, human societies react not evenly, or more effective, either because in the same group perceptions of the deviating phenomenon, either because the cultural and technical achievements vary from one social class to another and introduce spatial and temporal discontinuities in the mastery of the consequences of this phenomenon. In order to reverse the trend, and reconnect with the noticeable increase in yields of cowpea, several strategies and coping skills are developed by the people of the Municipality of Lokossa.

Indigenous Strategies Developed in the Study Area

As strategies, producers in marshy areas revealed that they anticipate the dates of sowing, i.e. for the account of the great season, all rain installed in February is conducive to the seed, the same for the short season, August is indicated. Mulching of the soil is made with leaves of maize and Cowpea. Which allows not only to slow the drying up of the ground

but still Cowpea contributes to the enrichment of the soil organic matter.

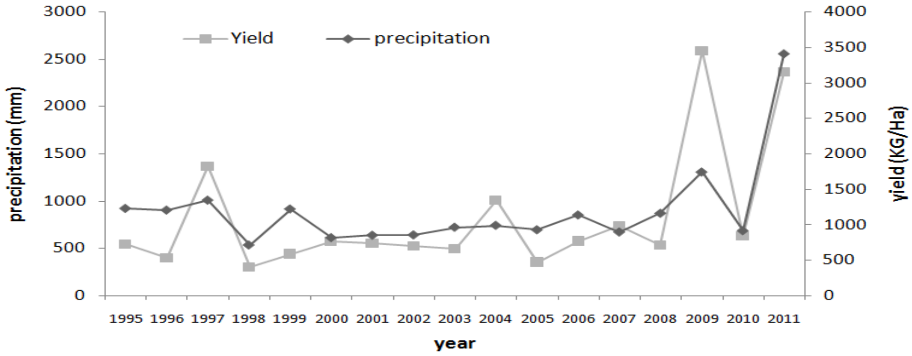

Figure 5: Relation between the Precipitation and the Yield of Cowpea

In response to the declining agricultural yields and the new climate context, producers have made the choice to adopt in their cropping system of new crop varieties proposed by the CSAE management agents. According to 80% of producers, varieties of Cowpea to short cycle and high productivity are now adopted as a response to the above listed elements. This includes varieties IT 81 D - 1137; IT 82 E - 32; IT 82 D - 849; IT 81 D - 994; IT 89 KD - 288, which are increasingly cultivated in the middle of study. Systems of combined crops produce the best yields per unit area (Adjahossou *et al.,* 2009). In the Municipality of Lokossa, field work revealed that producers (15%) forfacing the uncertainties of climate sometimes associate the corn culture to that of Cowpea to increase its performance as shown in the following picture. As confirmed by Paul do GBESSO *et al.,* 2013), Cowpea is a plant traditionally cultivated in Africa, in association more often with other food crops such as maize, millet, sorghum, etc. The follow picture shows the association of maize and Cowpea in a field at Lokossa. This practice is observed in almost all the villages in order to reduce the risk of loss related to the weather, to ensure their food and specially to enhance their poorer lands. Cowpea is suitable for cropping systems available in many parts of Africa and represents an important crop from the nutritional point of view. In addition to protein-rich seeds, its tender leaves are cooked as a vegetable, and accompany grain-based dishes; the tops are fodder for livestock. Associations of crops also depend on the crop water requirements. It should be noted that existing strategies at the local level must be taken into account and used to identify priority activities, instead of focusing on the development of models based on scenarios to assess future vulnerability and the long-term policy at national level. (Boko, 2009; IPCC, 2012 quoted by Doukpolo, 2014).

Picture: Association of Maize and Cowpea in a Field at Lokossa; Photography: SESSOU January, 2013

CONCLUSIONS

This study shows that the reduction or increase of the rainfall affects seriously the yield of cowpeas in the Municipality of Lokossa. It is also noticed the delay in the start of the rainy season, the bad distribution of rainfall and pocket of drought affects the length of growing season. This condition explained why the Cowpeas water demand not always be satisfied during the development of the plant in a comparison with requirements in water of crop. But in taking into account the specific properties of cowpea, farmers of this Municipality were able to integrate this crop in their different strategies for mitigation and adaptation to climatic changes.

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